THE BALDWIN LOCOMOTIVE WORKS

WALSCHAERTS VALVE GEAR

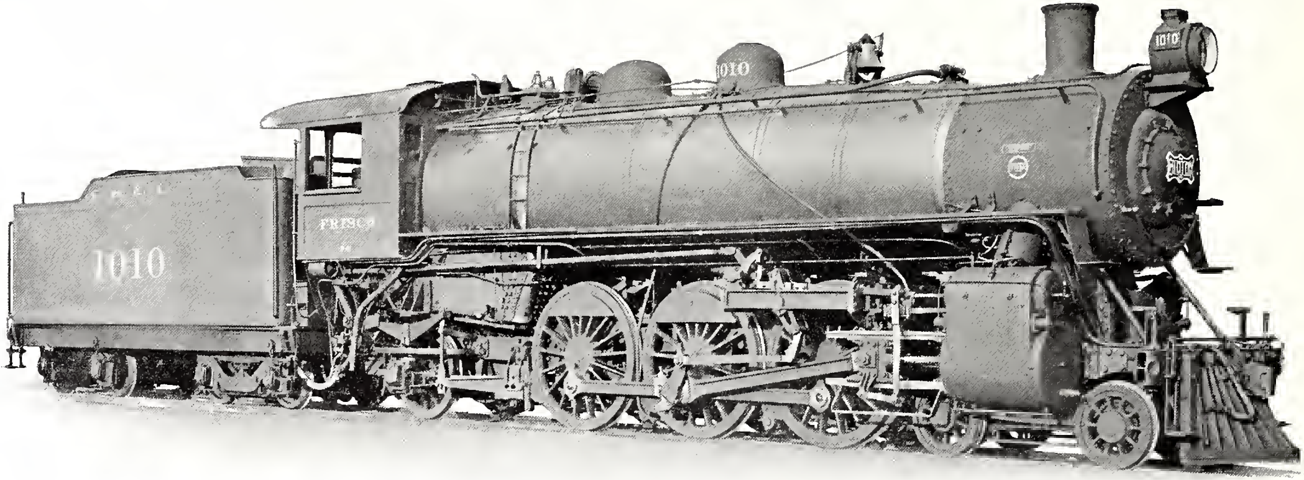
RECORD NO. 70

THE BALDWIN LOCOMOTIVE WORKS
PHILADELPHIA, PA., U. S. A.

WALSCHAERTS VALVE GEAR

CODE WORD—RECUAMENTO

RECORD NO. 70
REVISED AND REPRINTED 1913



PACIFIC TYPE LOCOMOTIVE WITH WALSCHAERTS VALVE GEAR
CHICAGO AND EASTERN ILLINOIS RAILROAD

Walschaerts Valve Gear

SINCE the year 1905, the Walschaerts valve gear has come into extensive use in American locomotive practice, and it is now more generally employed, especially on heavy power for road service, than any other form of motion. The principal advantage of this gear lies in the accessibility of its parts, which are placed entirely outside the driving wheels. This facilitates oiling, inspection and cleaning; operations which are frequently difficult to carry out in locomotives equipped with the Stephenson link motion. Furthermore, in heavy engines equipped with the Stephenson gear, the eccentrics must be made of large diameter to secure the required throw. This increases the velocity of the rubbing surfaces and also the tendency to heat, especially in the case of locomotives which have comparatively small wheels and are employed in high speed service. In the Walschaerts gear the various parts are pin-connected, and are easily lubricated; hence troubles due to heating are reduced to a minimum.

The Walschaerts motion is of the radial type, and it employs a link which is trunnioned at its middle point. The link is rocked by means of an eccentric rod, whose motion is usually derived from a return crank, secured to the main crank pin. The movement of the link is transmitted to the valve stem by a radius rod, whose length is equal to the link radius. This radius rod is pinned to the sliding link block, and can be raised or lowered by the reverse lever. When the block is above the link center, the engine runs in one direction, and when below the center, in the opposite direction; the

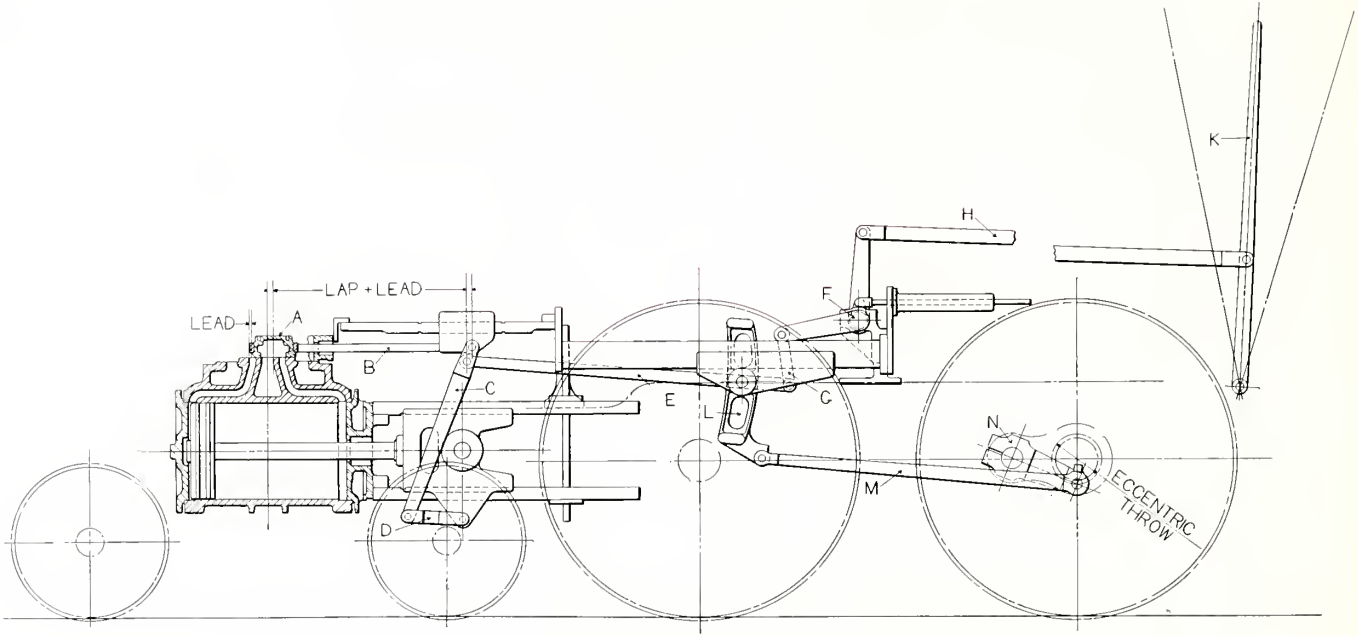


FIG. 1

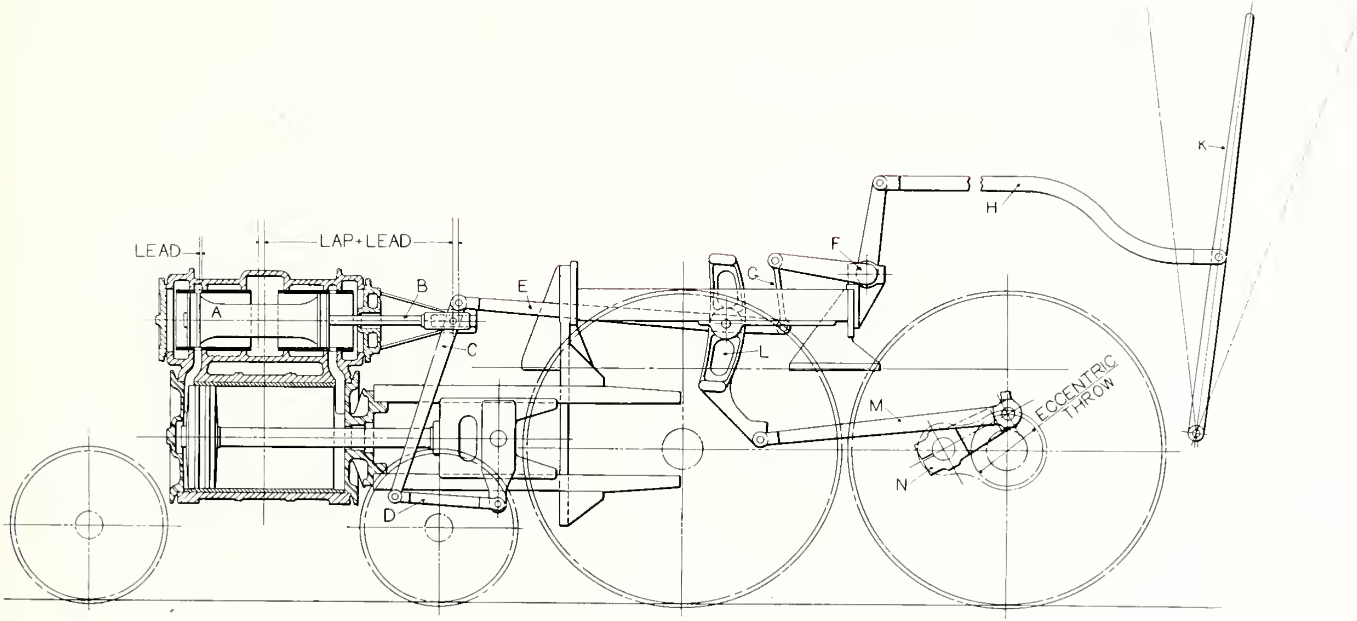


FIG. 2

direction of movement being determined by conditions to be subsequently explained.

The return crank on the main pin (known as the eccentric crank) is so set that, when the piston is at the extreme end of its stroke, the link stands in its middle position; and it is evident that if the radius rod were attached directly to the valve stem, the valve would also be in its middle position. When, however, the piston is at the end of its stroke, the valve should be displaced from its middle position by an amount equal to the steam lap plus the lead. In the Walschaerts gear the valve is given lead by a combining lever, which is attached to both the valve stem and radius rod, and is also connected, through a suitable link, to the crosshead. This combining lever is so proportioned that if the point of its connection to the radius rod be kept a stationary fulcrum, and the piston moved a distance equal to the stroke, the valve will be moved a distance equal to twice the lap plus the lead. Therefore when the piston is at the end of its stroke, the valve is displaced from its middle position a distance equal to the lap plus the lead, and the correct steam distribution is secured.

The accompanying diagrams show two arrangements of Walschaerts motion. Figure 1 represents a design used with outside admission slide valves, and Figure 2 a design used with inside admission piston valves. In both cases corresponding parts are similarly designated by letters, as follows:

A—valve
B—valve stem
C—combining lever
D—crosshead link
E—radius rod
F—reverse shaft
G—lifting link
H—reach rod
K—reverse lever
L—reverse link
M—eccentric rod
N—eccentric crank

The main pin is shown on the forward dead center, and the reverse lever is in its middle position, with the link block in the center of the link. A careful study of the diagrams reveals the following facts.

With a valve having *outside admission*—

The valve rod is connected to the combining lever at a point *above* the latter's connection to the radius rod.

If the block is in the *lower* half of the link when in forward gear, the eccentric crank *leads* the main pin.

If the block is in the *upper* half of the link when in forward gear, the eccentric crank *follows* the main pin.

With a valve having *inside admission*—

The valve rod is connected to the combining lever at a point *below* the latter's connection to the radius rod.

If the block is in the *lower* half of the link when in forward gear, the eccentric crank *follows* the main pin.

If the block is in the *upper* half of the link when in forward gear, the eccentric crank *leads* the main pin.

Inasmuch as the position of the valve, when the piston is at the end of its stroke, is dependent on the combining lever only, it is evident that the lead given by the Walschaerts gear is the same for all points of cut-off. This is the principal feature which distinguishes this gear from the Stephenson motion as far as steam distribution is concerned. All parts of the Walschaerts motion should be correctly laid out and constructed from a diagram, and the gear designed to give the lead most desirable for the usual running speed. The parts having been correctly made, it is impossible to alter the lead without seriously deranging the motion. In this respect the Walschaerts gear is less flexible than the Stephenson; but when the correct steam distribution is obtained it is less liable to derangement, and the engine is more easily kept "square."

The accompanying illustrations represent eight arrangements of this gear, as applied to recent locomotives of various types. The styles shown are briefly described as follows:

Figure 3 shows the gear as applied to an American type locomotive, with slide valves. The link bearings are bolted to the guide yoke, and the reverse shaft bearings to a cross-brace placed immediately ahead of the main driving wheels.

Figure 4 shows the gear as used on an Atlantic type locomotive. A cast steel bearer, placed between the two pairs of driving wheels, supports the link and reverse shaft bearings. The valve is of the piston type, with inside admission; and as the radius rod is down in forward gear, the eccentric crank follows the main pin.

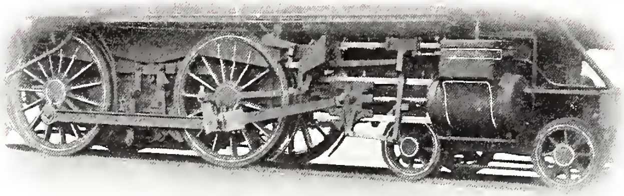


FIG. 3

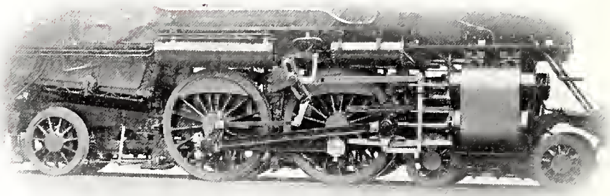


FIG. 4

Figure 5 shows an arrangement of motion as applied to a ten-wheeled locomotive with slide valves. The links are carried on longitudinal bearers, placed outside the leading pair of driving wheels.

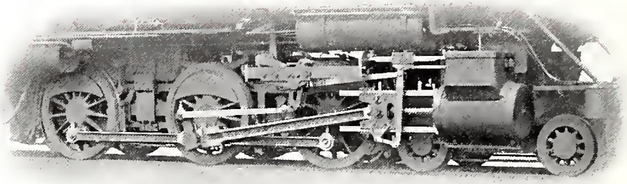


FIG. 5

Figure 6 shows an arrangement used on a Pacific type locomotive with inside admission piston valves. The valve rod is here supported by guides which are cast on an extension of the back steam-chest head.

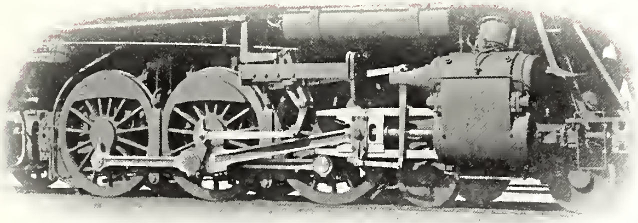


FIG. 6

Figure 7 shows a design of motion used when the steam chest center is inside the cylinder center. A rocker transmits the movement from the plane of the gear to the center of the steam chest. This is a satisfactory arrangement to apply when the cylinders are interchangeable with those of locomotives using the Stephenson link motion.

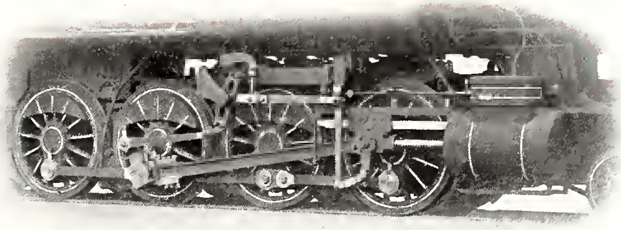


FIG. 7

Figure 8 shows the gear as applied to a Mikado type locomotive with slide valves and Ragonnet power reverse mechanism. A somewhat similar application, used with piston valves, is shown in Figure 9. In this case the locomotive is of the Sante Fe type, with five pairs of driving wheels.

Figure 10 shows a design of motion used on a large

Mallet articulated locomotive. The valves of the rear engine are arranged for inside admission, and those of the front engine for outside admission. The front and back reverse shafts are connected by a jointed reach rod, and the gears of the two engines are simultaneously controlled by the Ragonnet reverse mechanism.

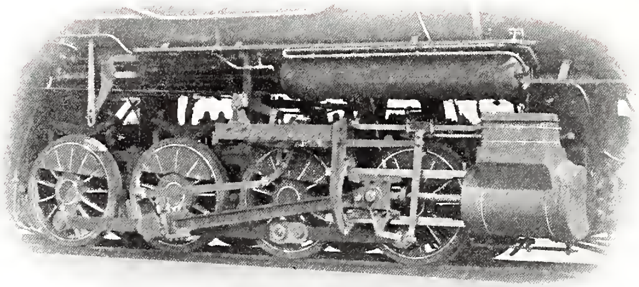


FIG. 8

All the gears illustrated are so arranged that the main guides can be lined up without disturbing the adjustment of the motion work.

The gears shown are typical of recent practice, but they by no means represent all the modifications in successful use. The general design of the engine influences, to a large extent, the arrangement of the motion.

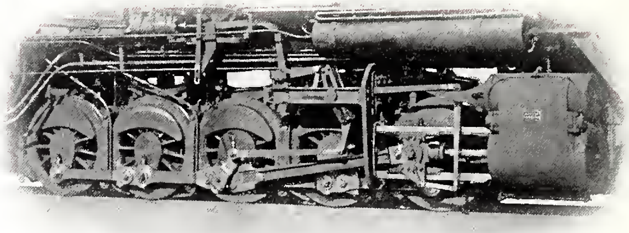


FIG. 9

Mention has been made of the fact that all parts of the Walschaerts gear must be laid down on a diagram in order to insure a correct steam distribution. If all the details could be made and assembled exactly to the drawings, the operation of "valve setting" would be

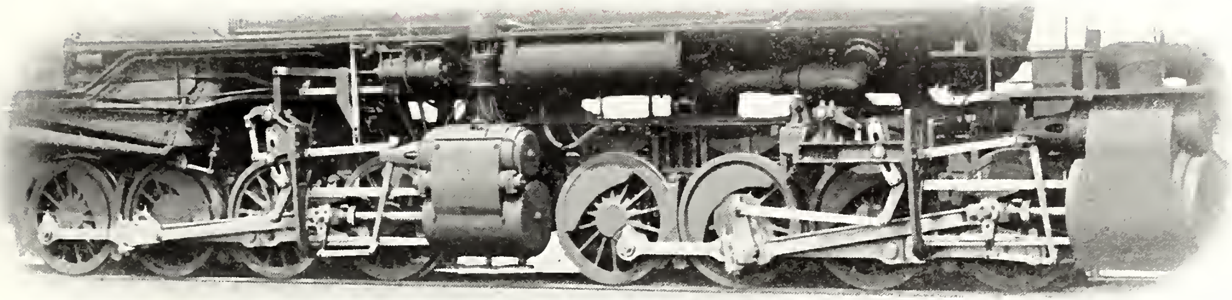


FIG. 10

unnecessary. In practice, however, such accuracy cannot be obtained; and after the gear has been assembled some adjustment is usually required.

Method of Setting Valves with Walschaerts Gear

Assuming that all detail parts have been checked with their respective drawings and that the main rod is up and the gear fully connected, the procedure is as follows:

1. Block the main driving boxes, allowing one-half inch over the central position for settling; viz.: add one-half inch to the dimension between the top of the frame and the center line of the driving journal, as given on the erecting diagram.

2. **Obtaining Exact Dead Centers.** Place the

main crank approximately six or eight inches below the forward dead center. Put a prick punch mark on any convenient place on the crosshead gib, and scribe with a tram or a pair of dividers the line A-A on the guide.

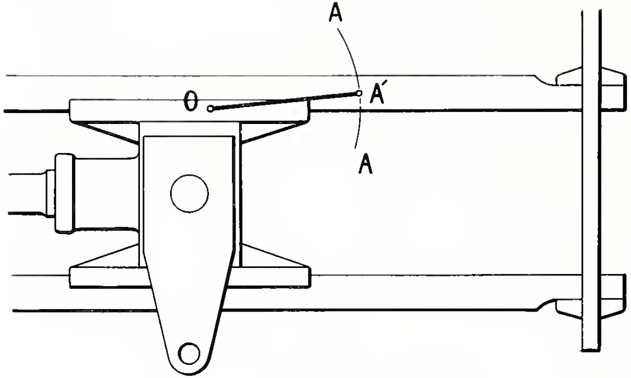


FIG. 11

Then prick punch the point A′ at any convenient place on the line A-A (see Figure 11).

Next prick punch the engine frame at any convenient place ahead of the driving wheel, and with a long tram scribe the line B-B on the tire. Prick punch the point B′ at a definite position (say one inch from edge of tire) on this line (see Figure 12).

Now revolve the wheel backward until the main crank comes above the forward dead center, stopping it when the tram used in Figure 11 reaches exactly from the point O on the crosshead to the point A′ on the guide (see Figure 11).

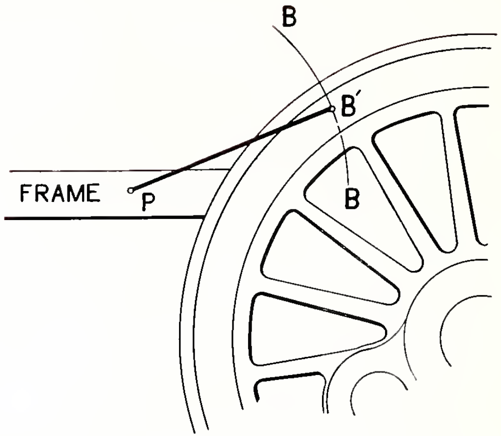


FIG. 12

Then re-tram the frame to the tire as in Figure

13, using the same tram and the same point P as in Figure 12.

Scribe the line C-C and punch the point C′ at exactly the same distance from the edge of the tire as previously used in locating B′. This operation will place the point B′ (previously obtained) at a distance Q from point C′.

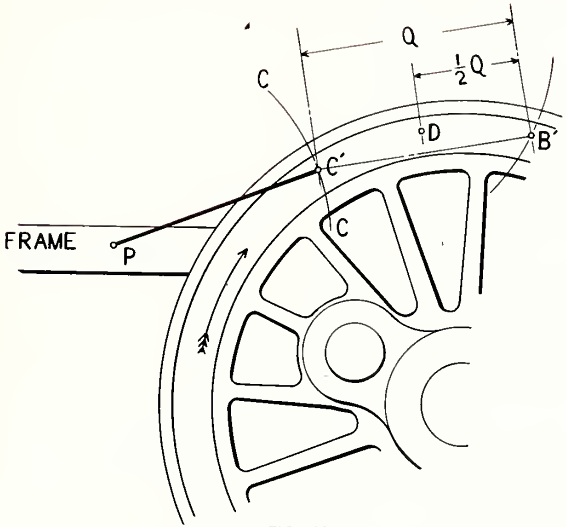


FIG. 13

Now prick punch the point D at a position exactly central between C′ and B′ and at the same distance from the edge of the tire that was used in their location (one inch was previously suggested).

Now if the wheel be revolved forward until the long tram reaches exactly from point P to point D, the main crank will be on the exact forward dead center.

Proceed in like manner to obtain the exact backward dead center, reversing the operation and using the same points on the crosshead and frame, and a new point (forward of the crosshead) on the guide.

The standard method used by The Baldwin Locomotive Works for marking these centers is shown on Figure 14. The trial points are indicated by a single punch mark only, while the final points are indicated by three punch marks, the outermost ones being the actual tram points (D-D′).

The points S and S′, as shown on Figure 14, are indicated in a similar manner; the outermost punch marks representing the actual tram points used for marking the half stroke positions.

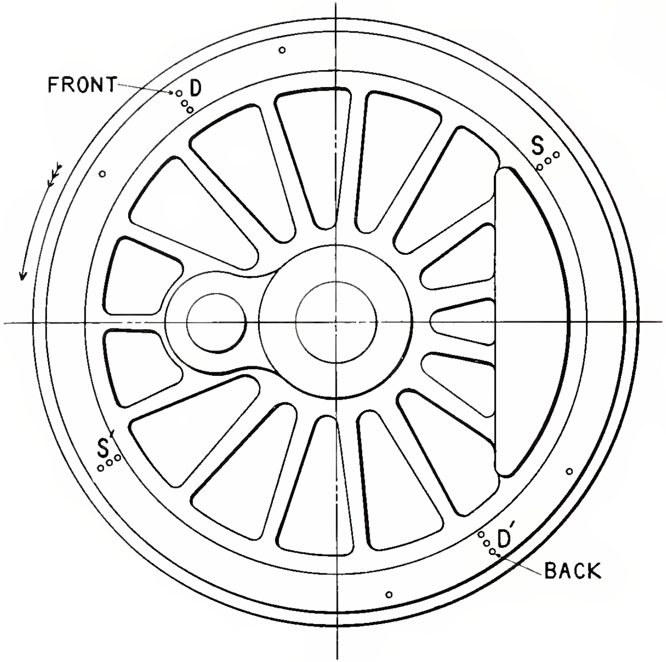


FIG. 14

To obtain the points S and S′, set the crosshead on the forward dead center and measure back on the guides one half the piston stroke, as shown on Figure 15.

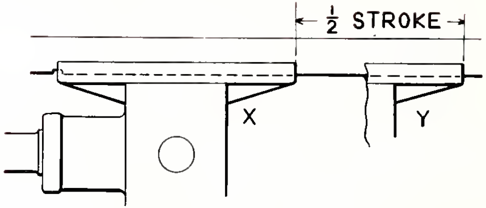


FIG. 15

Then revolve the wheel forward until the crosshead moves from position X to position Y. Now with the long tram obtain point S by tramming from point P on the frame (Figures 12 and 13), prick punching point S at the same distance from the edge of the tire as point D.

The opposite half stroke point S′ may be obtained by the same method, preferably revolving the wheel in the same direction (arrow on Figure 14) so that the influence of lost motion in the parts may be minimized.

The four important points on the stroke are now definitely established on the wheel, and are ready to be used for valve setting.

Note: If desired, any other positions of the stroke can be marked on the wheel by using the long tram and the method of procedure described above.

Setting of Outside Admission Slide Valves

1. With the ports exposed, place the valve with its steam edge just cutting off the ports (at each end successively), and prick punch the valve stem at points F and F′, obtained by tramming from any convenient place on the valve seat or shelf (see Figures 16 and 17). The distance between points F and F′ will be equal to twice the lap of the valve. When the valve is leading (main crank on either dead center) the port

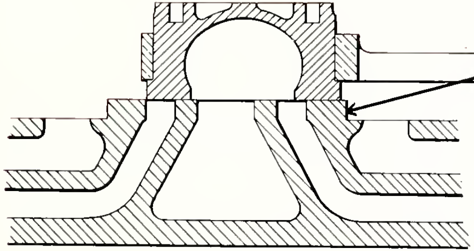


FIG. 16

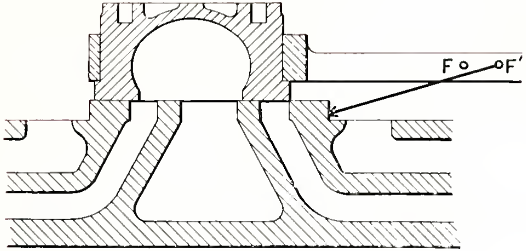


FIG. 17

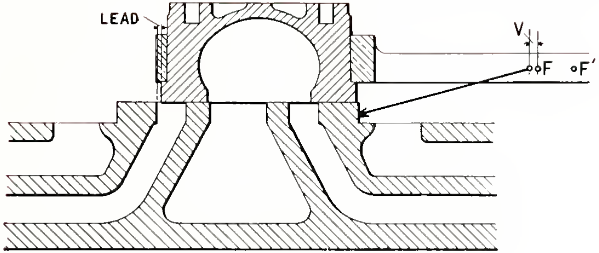


FIG. 18

should be open by an amount equal to the desired lead (see Figure 18).

If the tram is used with the valve on its lead, then the distance between the points so found and the point F on the valve stem will be equal to the lead (see dimension V on Figure 18).

With this statement in mind, proceed as follows:

2. Hook up the gear so that the link block is exactly central with the link. Place the main crank on the forward dead center, and tram to the valve stem. Revolve the wheel to the backward dead center, and again tram to the valve stem. Measure the distance between the points so obtained, and compare the same with the specification. The distance should be equal to twice the sum of the lap and lead. Variation from the specified figures means that an error exists in the combining lever, the upper and lower arms of which are made respectively proportional in length to twice the lap and lead and to the stroke of the piston. (See Figure 19).

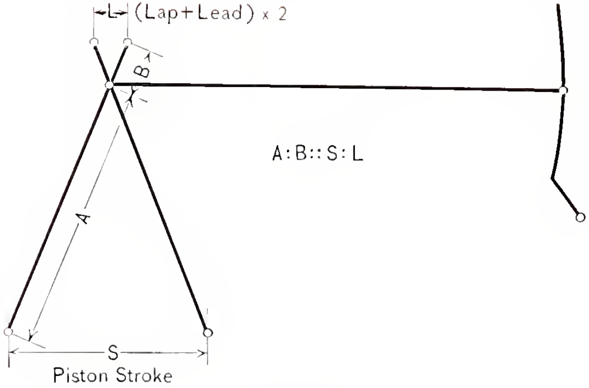


FIG. 19

Assuming that the distance L, as trammed on the valve stem, is found correct, the procedure is now as follows:

3. Place the gear in forward motion, with the link block at a point in the link that will give the specified maximum valve travel when the wheels are revolved in a forward direction (this position of the link block is obtained by experiment).

4. Place the main crank on the forward dead center, by tramming from P to D; and with the same tram

as used for marking the valve stem (Figures 16 and 17) scribe on the stem, measuring the distance between the point so obtained and the punch mark F. This distance should be exactly equal to the specified lead.

5. Revolve the wheel in a forward direction until the main crank is on the back dead center (tram from P to D′), and similarly scribe on the valve stem, measuring the distance between the point so obtained and the punch mark F′. This distance should also be exactly equal to the specified lead.

6. Place the gear in backward motion (as instruction No. 3) and examine for lead at the front and back exactly as described in instructions 4 and 5, except that the wheel must be revolved in a backward direction.

7. If all the points so found are exactly to specification, the valve setting is square. A check should now be made by placing the piston on the forward dead center, and moving the link block through its entire travel in the link. This should in no way disturb the position of the valve.

8. With the gear set for full stroke forward and full stroke backward, the maximum valve travel should be examined with the piston at half stroke; placing the wheel with the long tram between the points P and S and P and S′ respectively (see Figure 14). The travel so measured will not be exactly square at the front and back, as the points S and S′ represent half stroke measured from the piston travel, and do not take into consideration the angularity of the main rod.

Note On Travel Irregularities. The Walschaerts gear has inherent peculiarities that frequently cause slight irregularities in the travel of the valve. If, in full gear, this irregularity does not amount to more than one-quarter inch out of the square between the front and back positions of the valve, it may be ignored, and the squaring of the travel may be considered as nearly perfect as the design will allow.

In special cases it may be desirable to square the valve travel when the gear is hooked up to give the cut-off at which the engine is most frequently worked. Thus, on a passenger locomotive, the most satisfactory results may be secured when the travel is squared at one-third or one-half stroke cut-off. In such a case, a slight irregularity at full stroke will probably be unavoidable, but will not prove detrimental. In any event, the particular circumstances under which the engine is to work must determine at what point of cut-off the valve travel shall be squared.

9. In marking the forward and backward gear positions on the reverse quadrant of a "cold engine" an allowance toward the front of the quadrant must be made on each end, to correct for expansion when the engine is under steam. The amount of such allowance is a matter of judgment, but one-quarter to three-eighths inches can be considered sufficient for ordinary standard gauge engines.

Corrections

If, on trial, the valve gear is found to be out of square on the lead points, the following hypothetical cases will serve to explain the corrections that should be made.

For example, suppose the specification calls for the following:

Maximum valve travel, 5½"
Eccentric crank throw, 11"
Constant lead, ¼"
Outside lap of valve, 1"
Link block below link center in forward gear.

It is very important that the following dimensions check exactly with the drawings:

1. Length of combining lever between central fulcrum and upper and lower arm centers (see Figure 19, dimensions B and A).

2. Eccentric crank throw and length of crank arm.

In the case under consideration the prick punch marks on the valve stem (refer to Figures 16, 17) will be two inches from center to center (this is twice the valve lap).

3. A change in the length of the eccentric rod results in a change in the position of the valve, approximately in proportion to the eccentric throw and valve travel. In the present case, this is as eleven to five and one-half or as two to one. In other words, a change of one-quarter inch in the length of the eccentric rod will

move the valve approximately one-eighth inch when the link block is in full gear and the main crank is on the dead center.

4. The influence of eccentric rod changes on the direction (ahead or back) of the movement of the valve is explained by reference to Figure 20. An examination of Figure 20 will show that if the eccentric rod E is lengthened to E′, then the radius rod R will be moved ahead to the position R′, and the valve stem will be moved a distance X in the direction of the arrow, thus displacing the valve from position V to position V′.

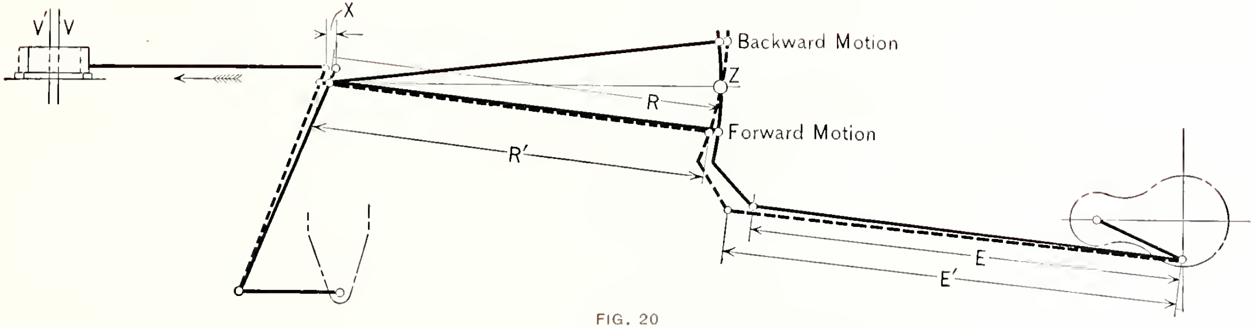


FIG. 20

5. The following rules can thus be formulated:

If the link block is below the link center when running ahead, then—

In forward motion

If the eccentric rod is lengthened, the valve is moved ahead.

If the eccentric rod is shortened, the valve is moved back.

In backward motion

If the eccentric rod is lengthened, the valve is moved back.

If the eccentric rod is shortened, the valve is moved ahead.

If the link block is above the center when running ahead, then, in each case, the valve will be moved in the direction opposite to that stated above.

6. Corrections made to the link radius rod will have approximately full influence on the movement of the valve, viz.: any variation in the radius rod will produce approximately the same variation in the movement of the valve.

7. The link fulcrum Z (see Figure 20) is a fixed point; therefore the direction of movement due to changes in the radius rod will vary directly with such changes, and the following rules can be formulated.

In either forward motion or backward motion,

To move the valve ahead, lengthen the radius rod the amount desired.

To move the valve back, shorten the radius rod the amount desired.

This is true whether the link block is above or below the link center in forward gear.

8. With these facts in mind, two hypothetical cases will be considered.

Hypothetical Case No. 1

Let it be assumed that, on tramming to the valve stem with the main crank on the dead centers, the following irregularities in the lead are noticed for the engine under consideration. The dots on the diagrams represent the prick punch marks F and F′ (see Figure 17) on the valve stem, while the crosses represent the irregularities in the lead when trammed to the valve stem (see Figure 21).

9. The first procedure will be to divide the error between the forward and backward motions, as follows:

Error in forward motion—

Front, 3/8″ — 1/4″ lead = 1/8″ error
Back, 1/4″ lead — 1/8″ = 1/8″ error

To square the lead, the valve must be moved 1/8″ ahead.

Error in backward motion—

Front, 7/16" — 1/4" lead = 3/16" error
Back, 1/4" lead — 1/16" = 3/16" error

To square the lead, the valve must be moved 3/16" ahead.

As the errors in the two motions occur in the same direction, it follows that the greater one partially neutralizes the effect of the lesser, and that the combined or average error will be the difference between the two, viz.: three-sixteenths inches minus one-eighth inch equals one-sixteenth inch average error.

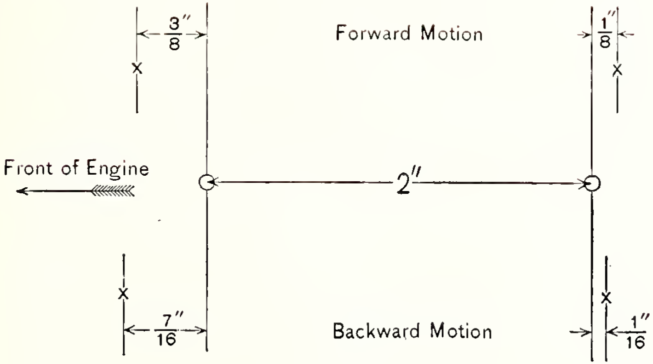


FIG. 21

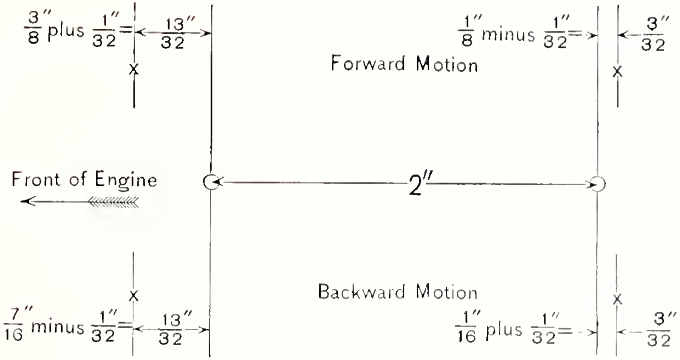


FIG. 22

10. To divide an average error of one-sixteenth inch equally about a central point, it will be necessary to move the valve one-half this amount, or one-thirty-second inch (in this case one-thirty-second inch back in forward motion).

According to rule 3, the eccentric rod must be shortened one-sixteenth inch (in the proportion of two to one) to move the valve one-thirty-second inch. When this has been done the valve stem points will tram as shown in Figure 22.

11. The errors in forward and backward motion have thus been equalized, and it remains only to square the lead front and back for both motions. The valve as now standing is five-thirty-seconds inches too far back to equalize the lead, viz.:

$^{13}/_{32}'' - {}^{1}/_{4}''$ lead $= {}^{5}/_{32}''$ error front.

$^{1}/_{4}''$ lead $- {}^{3}/_{32}'' = {}^{5}/_{32}''$ error back.

12. As the influence of the radius rod is direct (see rules 6 and 7) it follows that by lengthening this rod the amount required (five-thirty-seconds inches) the valve will be squared, and can be trammed to the dimensions shown by Figure 23. These dimensions are the ones required by the specification.

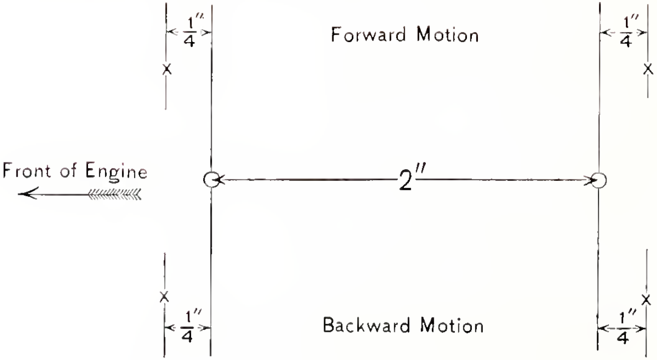


FIG. 23

13. The valve has thus been squared and the errors corrected in Hypothetical Case No. 1, by the changes noted below:

Eccentric rod shortened $^{1}/_{16}''$

Link radius rod lengthened $^{5}/_{32}''$

14. A final trial of the valve and cut-off, etc., can now be made in the previously described manner.

Hypothetical Case No. 2

Let it be assumed that on tramming for lead, results are obtained as represented by Figure 24.

15. Divide the error between the forward and backward motions as follows:

Error in forward motion—

Front, $^{7}/_{16}'' - {}^{1}/_{4}''$ lead $= {}^{3}/_{16}''$ error
Back, $^{1}/_{4}''$ lead $- {}^{1}/_{16}'' = {}^{3}/_{16}''$ error

To square the lead, the valve must be moved $^{3}/_{16}''$ ahead.

Error in backward motion—

Front, 1/4″ lead — 3/16″ = 1/16″ error
Back, 5/16″ — 1/4″ lead = 1/16″ error

To square the lead, the valve must be moved 1/16″ back.

As the errors in the two motions occur in opposite directions, it follows that they augment each other, and that the combined or average error will be the sum of the two, viz.: three-sixteenths inches plus one-sixteenth inch equals one-quarter inch average error.

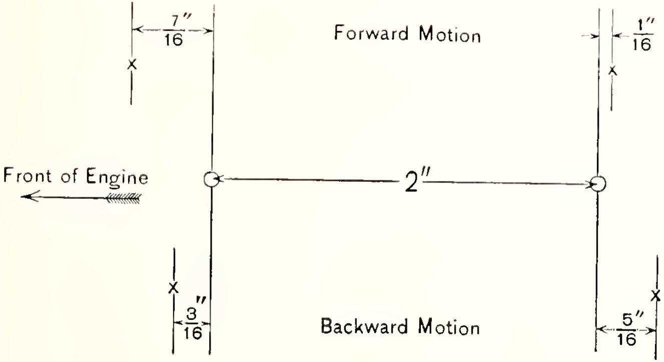


FIG. 24

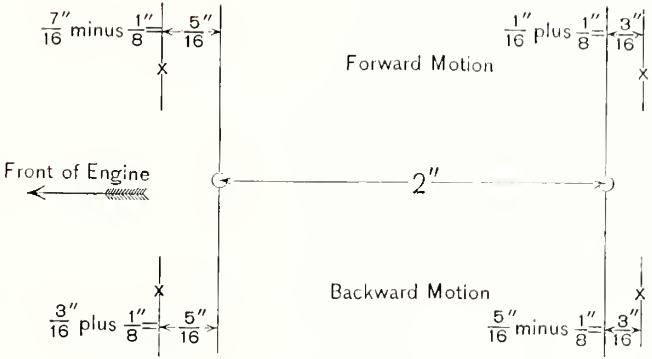


FIG. 25

16. To divide this error equally about a central point, it will be necessary to move the valve one-half the amount, or one-eighth inch (in this case one-eighth inch ahead in forward motion).

According to rule No. 3, the eccentric rod must be lengthened one-quarter inch (in the proportion of two to one) to move the valve one-eighth inch. When this has been done, the valve stem will tram as shown in Figure 25.

17. The errors in forward and backward motion have thus been equalized, and it remains only to square the lead front and back for both motions. The valve as now standing is one-sixteenth inch too far back to equalize the lead, viz.:

$^5/_{16}''$ — $^1/_4''$ lead = $^1/_{16}''$ error front.

$^1/_4''$ lead — $^3/_{16}''$ = $^1/_{16}''$ error back.

18. To move the valve ahead one-sixteenth inch the link radius rod must be lengthened one-sixteenth inch (see rules 6 and 7) and the lead will then be squared. When trammed for lead, the results will be as shown by Figure 23. These dimensions are the ones required by the specification.

19. The lead has been squared and the errors in Hypothetical Case No. 2 have been corrected by the changes noted below:

Eccentric rod lengthened $^1/_4''$

Link radius rod lengthened $^1/_{16}''$

20. Trial of the valve travel and cut-off, etc., can now be made in the manner previously described.

From the above it is evident that the errors in forward and backward motion are equalized by changing the length of the eccentric rod; and the lead is then squared by changing the length of the radius rod. Theoretically the radius rod should not be changed; but the amount necessary is so slight, that it makes practically no difference in the movement of the valve.

Setting of Inside Admission Piston Valves

The method of setting inside admission piston valves is generally similar to that previously described. It must be remembered, however, that to perform corresponding functions, this valve moves in a direction opposite to that of the slide valve. When setting piston valves, the steam chest heads should be removed, for the sake of convenience. The line and line positions of the valve, are determined by observation through peep holes provided for the purpose. In this way, the points F and F′ are located on the valve stem, by tramming from any convenient point on the back wall of the steam chest.

(Figures 26 and 27). The lead points on the valve stem can thus be obtained by placing the crank on the dead centers, and again tramming from the steam chest wall. (Figure 28). The test for lead is made as described in paragraph 2 on page 16, the combining lever occupying positions as shown in Figure 29.

The lead in full gear, with this style of valve, is examined precisely as described in paragraphs 3 to 8,

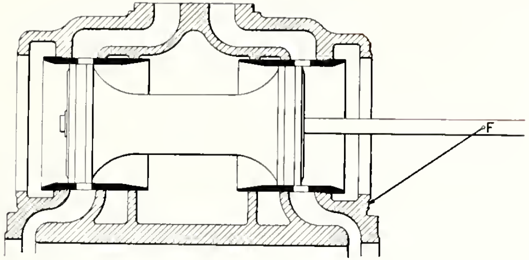


FIG. 26

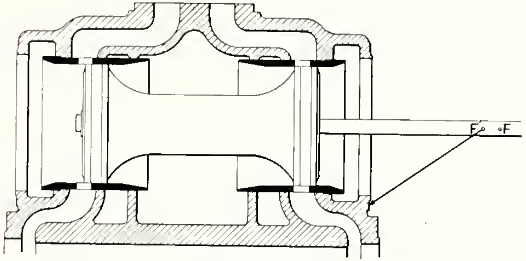


FIG. 27

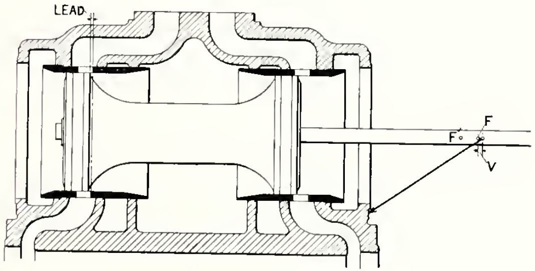


FIG. 28

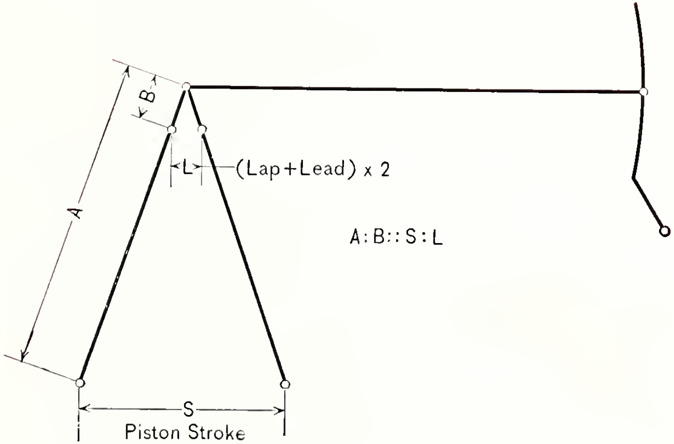


FIG. 29

pages 16 and 17. Reference should be made to Figures 26 and 27, instead of to Figures 16 and 17.

Corrections

As in the case of the slide valve, methods used for correcting errors can be best explained by two hypothetical cases. For example, suppose the specification of a locomotive having inside admission piston valves, calls for the following:

Maximum valve travel, $5^{3}/_{4}''$
Eccentric crank throw, $15^{1}/_{2}''$
Constant lead, $^{1}/_{4}''$
Steam lap of valve, $1''$
Link block below link center in forward gear.

The influence of eccentric rod changes on the direction (ahead or back) of the movement of the valve, is explained by reference to Figure 30. An examination of this figure will show that if the eccentric rod E is

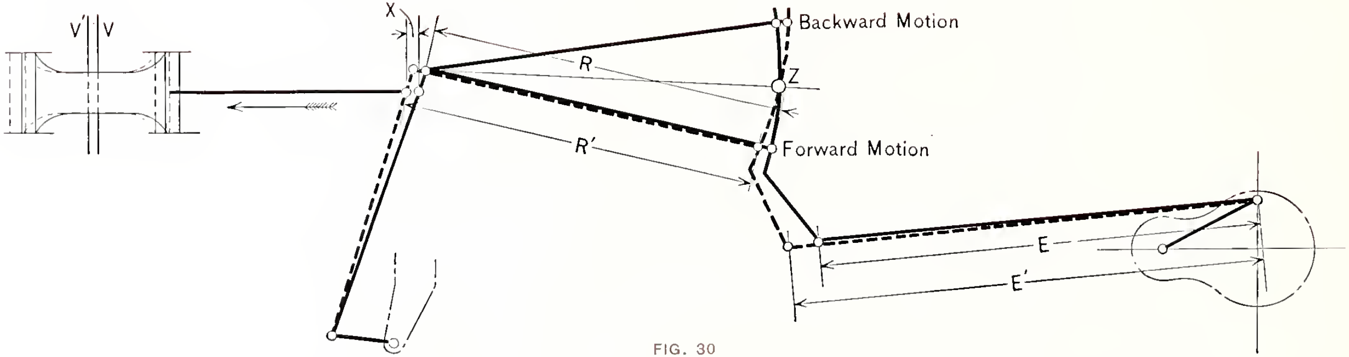


FIG. 30

lengthened to E′, then the radius rod R will be moved ahead to the position R′, and the valve stem will be moved a distance X in the direction of the arrow, thus displacing the valve from position V to position V′. Therefore, the rules applying in the case of outside admission slide valves also apply to this style of valve, as follows:

In forward motion—

If the eccentric rod is lengthened, the valve is moved ahead.

If the eccentric rod is shortened, the valve is moved back.

In backward motion—

If the eccentric rod is lengthened, the valve is moved back.

If the eccentric rod is shortened, the valve is moved ahead.

If the link block is above the center when running ahead, then, in each case, the valve will be moved in the direction opposite to that stated above.

In any case, regardless of whether the gear is in forward or backward motion—

To move the valve ahead, lengthen the radius rod the amount desired.

To move the valve back, shorten the radius rod the amount desired.

It must be remembered that with an inside admission valve, the front port opening is increased if the valve is moved ahead, and the rear port opening is increased if the valve is moved back.

Bearing these facts in mind, two hypothetical cases will now be considered.

Hypothetical Case No. 1

Let it be assumed that, on tramming to the valve stem with the main crank on the dead centers, the following irregularities in the lead are noticed for the engine under consideration. The dots on the diagram represent the prick punch marks F and F′ (see Figure 27) on the valve stem, while the crosses represent the irregularities in the lead when trammed to the valve stem (see Figure 21). These irregularities are the same as those used in the corresponding case for slide valves, therefore the same diagrams are referred to. In the present case, however, as the valve is arranged for inside admission, the lead marks for the front steam port will appear on the back end of the valve stem, and those for the back steam port on the front end. A reference to figures 26, 27 and 28 will make this clear. In other words, when applying figures 21–25 to a locomotive with inside admission valves, the front of the engine should be considered on the right instead of on the left. The terms "front" and "back" in the text apply to the steam ports, and not to the positions of the marks on the valve stem.

1. The first procedure will be to divide the error between the forward and backward motions, as follows:

Error in forward motion—

Front, $^3/_8''$ — $^1/_4''$ lead = $^1/_8''$ error
Back, $^1/_4''$ lead — $^1/_8''$ = $^1/_8''$ error

To square the lead, the valve must be moved $^1/_8''$ back.

Error in backward motion—

Front, $^7/_{16}''$ — $^1/_4''$ lead = $^3/_{16}''$ error
Back, $^1/_4''$ lead — $^1/_{16}''$ = $^3/_{16}''$ error

To square the lead, the valve must be moved $^3/_{16}''$ back.

As the errors in the two motions occur in the same direction, it follows that the greater one partially neutralizes the effect of the lesser, and that the combined or average error will be the difference between the two, viz.: three-sixteenths inches minus one-eighth inch equals one-sixteenth inch average error.

2. To divide an average error of one-sixteenth inch equally about a central point, it will be necessary to move the valve one-half the amount or one-thirty-second inch (in this case, one-thirty-second inch ahead in forward motion).

In the engine now under consideration, the eccentric crank throw is fifteen and one-half inches and the valve travel five and three-quarters inches. Hence the ratio of eccentric throw to valve travel, is approximately as two and seven-tenths to one. Therefore, according to rule 3, page 18, the eccentric rod must be lengthened two and seven-tenths times one-thirty-second, or approximately five-sixty-fourths inches to move the valve ahead one-thirty-second inch. When this has been done, the valve stem points will tram as shown in Figure 22.

3. The errors in forward and backward motion have thus been equalized, and it remains only to square the lead front and back for both motions. The valve as now standing is five-thirty-seconds inches too far ahead to equalize the lead, viz.:

$^{13}/_{32}'' - {^1/_4}''$ lead $= {^5/_{32}}''$ error front.

$^1/_4''$ lead $- {^3/_{32}}'' = {^5/_{32}}''$ error back.

As the influence of the radius rod is direct (see rules 6 and 7, page 20), it follows that by shortening the rod five-thirty-seconds inches, the valve will be moved back that amount and the lead squared. The valve stem can then be trammed to the dimensions shown in Figure 23. These dimensions are the ones required by the specification.

4. The valve has thus been squared and the errors corrected in Hypothetical Case No. 1, by the changes noted below:

Eccentric rod lengthened $^5/_{64}''$

Radius rod shortened $^5/_{32}''$

5. A final trial of the valve and cut-off, etc., can now be made in the previously described manner.

Hypothetical Case No. 2

Let it be assumed that on tramming for lead, results are obtained as represented by Figure 24.

6. Divide the error between the forward and backward motions, as follows:

Error in forward motion—

Front, $^7/_{16}'' - {^1/_4}''$ lead $= {^3/_{16}}''$ error

Back, $^1/_4''$ lead $- {^1/_{16}}'' = {^3/_{16}}''$ error

To square the lead, the valve must be moved $^3/_{16}''$ back.

Error in backward motion—

Front, $^1/_4''$ lead $- {^3/_{16}}'' = {^1/_{16}}''$ error

Back, $^5/_{16}'' - {^1/_4}''$ lead $= {^1/_{16}}''$ error

To square the lead, the valve must be moved $^1/_{16}''$ ahead.

As the errors in the two motions occur in opposite directions they augment each other, and the combined or average error will be the sum of the two, viz.: three-sixteenths inch plus one-sixteenth inch equals one-quarter inch average error.

7. To divide the error equally about a central point, it will be necessary to move the valve one-half the amount, or one-eighth inch (in this case one-eighth inch back in forward motion).

According to rule No. 3, page 18, the eccentric rod must be shortened two and seven-tenths times one-eighth inch, or approximately eleven-thirty-seconds inches, to move the valve one-eighth inch. When this has been done, the valve will tram as shown in Figure 25.

8. The errors in forward and backward motion have thus been equalized, and it remains only to square the lead front and back for both motions. The valve as now standing is one-sixteenth inch too far front to equalize the lead, viz.:

$^{5}/_{16}'' - {}^{1}/_{4}''$ lead $= {}^{1}/_{16}''$ error front.

$^{1}/_{4}''$ lead $- {}^{5}/_{16}'' = {}^{1}/_{16}''$ error back.

9. To move the valve back one-sixteenth inch, the link radius rod must be shortened one-sixteenth inch, (see rules 6 and 7, page 20) and the lead will then be squared. When trammed for lead, the results will be as shown in Figure 23. These dimensions are the ones required by the specification.

10. The lead has been squared and the errors in Hypothetical Case No. 2 have been corrected by the changes noted below:

Eccentric rod shortened $^{11}/_{32}''$

Link radius rod shortened $^{1}/_{16}''$

11. Trial of the valve travel and cut-off, etc., can now be made in the manner previously described.

Setting of Outside Admission Piston Valves

With valves of this type, the arrangement of the gear is the same as that used with outside admission slide valves, and the method of setting is the same. The line and line positions of the valve, however, must be observed through peep holes, as in the case of the inside admission piston valve.

Breakdowns

The handling of the Walschaerts gear in the event of a breakdown, presents no special difficulties. It is usually desirable, if possible, to take down both the eccentric rod and main rod. The cross head and valve stem can then be securely blocked, exactly as in the case of an engine equipped with the Stephenson gear. The radius rod should be disconnected from the reverse shaft by removing the lifting link. If the valve is blocked in its middle position, the cylinder on the damaged side will be cut out.

If the main rod, crosshead and piston on the damaged side are in a condition to run, the main rod may be left up, provided there are relief valves in the cylinder heads. The relief valves should be removed, so that the cylinder can be lubricated and excessive compression avoided. With the eccentric rod down, and the valve securely blocked in its middle position, the engine can then be run with the other side. It is of course necessary, in this case, to remove the crosshead link, and fasten the combining lever in forward position. The foot of the lever can readily be secured to one of the cylinder cocks.

If the damage is confined to the eccentric crank or rod, or to the lower end of the link, and the latter is still supported on its trunnions, the main rod may be left up, and the valve operated by the combining lever. To accomplish this, take down the eccentric rod, disconnect the radius rod from the reverse shaft, and secure the link-block exactly at the center of the link. The maximum port opening on the damaged side will now be equal to the lead, and the cut-off will be very short; but the steam will do at least some work, and the engine can be reversed and both the cylinders lubricated.

The Baldwin Locomotive Works

Philadelphia, Pa., U. S. A.

Builders of

Passenger Locomotives
Freight Locomotives
Switching Locomotives
Logging Locomotives
Plantation Locomotives
Locomotives for Rack Railroads
Geared Truck Locomotives
Heavy Locomotives for Special Service
Locomotives for Mills or Furnaces
Electrical Locomotives
Trucks
Mine Locomotives
Oil-Burning Locomotives
Gasoline Locomotives
Compressed-Air Locomotives

Specifications, proposals and full particulars furnished upon application

BLW